A GUIDE TO SUN, WIND AND WOOD ENERGY

for
CONSUMER AND CORPORATE AFFAIRS

by
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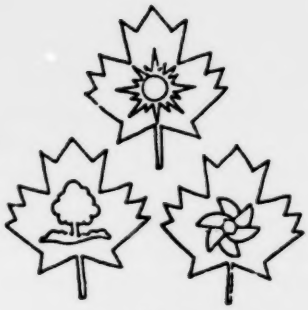

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This consumers guide introduces renewable energy technologies in Canada, focusing on solar, wind and wood equipment. The field of renewable energy is too new and is changing too rapidly to be able to identify the best systems or approaches. However, some trends can be perceived (based on the experience of people using the technologies) and appropriate questions formulated to serve as a basis for selecting the most suitable and efficient equipment.

No answers are given in this guide; simply some directions for becoming an <u>educated</u> consumer. Some perspectives on the potential and limitations of the technologies are important for the public to gain understanding of this emerging field.

Included is an explanation of key economic factors relevant to the use of the technologies as well as an illustrated glossary of terms which serves to familiarize the consumer with the jargon associated with these technologies.

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INTRODUCTION

If you're considering a major purchase or investment there are some guidelines to follow which will ensure that your choice is a wise one. The task of making the right choice is especially difficult in an emerging field like renewable energy since the technologies are still developing, and there is no set standards or long-term examples to follow when comparing products. To make matters more complex these new technologies have a language or jargon of their own. The average consumer may soon get lost and confused with talk of 'f-chart efficiency curves' and'galvanic corrosion.'

What questions do you ask when investigating a system? How do you assess the merits of each product in terms of its efficiency, ease of repair or expected lifetime? How can you be guaranteed access to the sun or wind when considering installing equipment? The answers to these questions are made even more difficult by the tremendous variety of equipment and services available. Furthermore, the application of a system varies considerably under different circumstances, making it difficult to judge one system against another in absolute terms. The intial cost of the system, its expectant lifetime, efficiency, the amount of personal labour required,

location, and its integration with the house and neighbourhood will vary greatly from one system to the next.

The difficulties involved in entering the field of renewable energy shouldn't discourage you, but rather should encourage you to become aware of the importance of being an educated consumer. Taking the time and trouble to learn the ins and outs of renewable energy will ultimately result in a better and more efficient system. Manufacturers and distributors will respond to an educated public by competing with each other and backing up their claims. The intent of this consumers guide is not to suggest which one of the scores of available systems is the best. No one can do that yet. What this report can do is raise the appropriate questions and suggest an approach to becoming an educated consumer.

When you are at the stage of seriously thinking of buying, it is important to understand your limitations. With your new-found expertise you will be able to assess many things, but there will probably be a point at which professional expertise should be sought. The beauty of these technologies is that they are relatively simple and comprehensible. However, you may require help of an engineer or architect. Experts may be of help in determing or checking if your heat

storage or demand calculations are correct. You may also want to check that the system is designed to be properly integrated with your home. Similarly, these technologies are simple enough that a handyperson could install a packaged system or even build one from scratch. Nevertheless, there may still be a place for professional consultation or work, as mistakes can be costly.

The following points are directed specifically to the person shopping for a commercial system. This information is also applicable to those who are looking for components to build their own systems. As in any purchase, it's important to shop around to get a sense of what the market has to offer. The basis for a decision will ultimately be the total cost of the system versus the total energy it will supply. Out of this will come an energy figure per dollar invested, or 'BTU per buck' as some call it. For example, a system that delivers twenty per cent less energy may be the better investment if it costs thirty per cent less. The main parameters to look at are:

- the initial capital costs;
- the operating costs;
- the expected maintenance costs;
- the efficiency of the system;
- the location of the system;
- the energy demand on the system and its expected lifetime.

Some of the features to look for in any system are durability, ease of repair, compatibility of the components with each other and with the auxiliary heating system and integration with the house. You must remember to base your judgement of a product on the reputation of the seller. Find the names and addresses of previous buyers for firsthand information about the system's performance and to find out if they are happy with it. Make sure to have the company you're buying from explain what their claims mean. Efficiency claims vary tremendously depending on what is being measured. Obtain these claims in writing. Be sure to find out what kind of guarantee comes with the system or components; that is, ask what it includes and how long it lasts. This should also be in writing. Find out if they will service the components they sell or if they just tell you to look in the yellow pages. You can be sure that by becoming an educated consumer and demanding clarification and written guarantees for all manufacturer claims, better products and services will be offered.

The future involvment of government in the implementation of renewable energy technologies should not be ignored. There are a variety of avenues the government can take which would provide substantial support for renewable energy. Among these are the possibility of tax breaks or subsidies for capital equipment, low interest mortgages, guarantee of sun rights, and the

establishment of standards of equipment performance. The implementation of any of these possibilities could change the whole economic picture and would have far reaching effects on the extent and timing with which renewable energy is developed in Canada. The economics section contains examples of some of the effects. As a consumer, you have an obligation to let all levels of government know what they should be doing to help you. An educated and vocal public can have a great effect.

SOLAR SPACE AND WATER HEATING

The concept of solar heating has captured the imagination of Canadians over the past few years. Hundreds of people are considering building a solar home or retrofitting their current house. Many people want to share in the excitement of being part of a pioneer movement. There are many considerations that prompt people to investigate or utilize heat from the sun. Some are impressed by its environmental and energy saving implications. Others are striving to achieve a personal independence and control over their own resources. Still others see solar heating as a political or anti-nuclear statement. Certainly these are all valid reasons, ones that point out the advantages and potential of solar heating. However, the decision to go solar generally comes down to one common denominator. Is it economical?

Generally, when investing in a solar heating system the most important criterion is BTU per dollars; i.e. how much energy does the solar system supply (or replace) for the money invested? This kind of analysis has four major components:

- the initial cost;
- the operation and maintenance costs;
- lifetime of the system;
- the energy delivered.

These are affected in different ways by the location, the site orientation, the collector angle, the materials used, the size and type of system and the installation techniques. It is virtually impossible to simply go to a manufacturer or distributor of solar hardware and say 'I want a solar system'. Perhaps you could if you are prepared to put a great deal of money into it; however, the majority of people are faced with the long (but not necessarily tedious) job of becoming familiar with the various options that are available. For example, it is generally more economical to improve the insulation in a house than to install a solar system. This should be done in any event. Similarly, an appropriate design that initially incorporates passive solar heating features will be more effective and economical than adding an active solar system.

Once you decide to explore solar heating with a view to building a system it is important to become an educated consumer. Read this report and read the appropriate books. Talk to people with similar interests and especially those who have already gone through the learning process of installing and living with a solar system.

SITE

One of the first questions to ask is, 'Is my site appropriate for solar heating?' To answer this, you must consider the orientation, tilt and access.

Orientation

The collector area (active or passive) is best oriented due south. This may vary according to local climatic conditions, but generally speaking a variance of as much as 20° east or west of south will not seriously affect collector performance.

Tilt

Generally a collector oriented due south will have a tilt equal to the latitude $+15^{\circ}$ for space heating. This tilt maximizes the collection of solar radiation during the winter. A collector used for domestic hot water is usually tilted at an angle equal to the latitude, as it is used all year. The angle may vary up to 15° from the optimum without seriously affecting the performance. Even 30° variations can be tolerated, thus allowing a vertical wall(90°) to be used as a collector area for space heating.

Access

The collector must be free from any existing or potential shadowing when it is in operation, especially in the three hours before and after solar noon. As yet there is no

guaranteed access to the sun in Canada; laws governing solar rights have not been established.

Other climatic and microclimatic features of the site can affect the system's operation. These include wind (which reduces the efficient operation of collectors), vegetation and water or snow which can act as a reflector surface.

TYPE OF SYSTEM

The biggest choice in determing your active solar system is whether to use an air-type system or a water-type system. Using an air-type collector with a rockbed storage has certain advantages:

- there are no freezing or boiling problems;
- small leaks are insignificant;
- heat exchangers are not required;
- they can be installed at moderate cost and are relatively easy to construct;
- they allow for a large temperature stratification in the storage.

The disadvantages are that a larger storage volume is needed for an equivalent heat capacity and large air ducts are necessary.

A water or liquid collector using water as storage has certain advantages;

- relatively small storage area is needed, about a third of the space required by rock storage;

- less space required for piping;
- some types of collectors and heat distribution systems are only compatible with water-type systems.

The disadvantages of a water system include freezing or corrosion problems as well as the possibility of leakage.

SIZE OF SYSTEM

Most of the solar houses in Canada today have short term storage systems which can provide heat for two or three days of cold or cloudy weather. They can supply anywhere from between 40 to 70 per cent of the space-heating requirements over the year. Generally, collector area ranges from one quarter to one third of the floor area of the living space. The optimum will vary from house to house.

The storage volume required is related to the collector area. For air systems, as little as ½ cubic foot of crushed rock for each square foot of collector area is used, although this figure varies. The recommended storage volume for a water-type system is usually two gallons of water for each square foot of collector. However, there are houses in Canada which use storage volumes of up to twenty-five gallons per square foot. Two other important storage systems (both still rare) are the annual heat storage system and eutectic salt storage. An annual heat storage system uses up to 60,000 gallons of water to store heat collected in the summer for use during the winter. This can provide 100 per cent solar heating for the house. Eutectic salts store heat in the form of latent heat of fusion. Its main advantage is that a very small storage

volume is required. Four solar houses using eutectic salts for storage have been built in Canada over the past year.

COMMERCIAL SYSTEMS VS. DO-IT-YOURSELF

To install a solar heating system in an existing house is a major job and not one that can be done incrementally. If you intend to contract out the job, it is much better to obtain a contractor who has had previous experience in this kind of work. This is advantageous because the contractor will be able to do the work in half the time (and therefore at a substantial saving), and he will not have to experiment. However, even if the contractor you choose has built several solar systems, it will still be an expensive undertaking. Costs range anywhere from $5000 to over $15,000 (including labour), depending on the size and type of system and the house onto which it is being added.

Whether or not this is an economical proposition must be carefully weighed against the energy it will supply, the expected lifetime of the system, the current and projected costs of conventional heating, and the philosophical motives for becoming a 'sunbuilder.'

An alternative to employing contractors is to buy the components and install the system yourself. Many distributors provide design services or will assist you by assessing your own design. If you are willing to supply the

labour, substantial savings will be realized. If you have initiative, feel you are a competent handyperson, and have time to devote to a system, you can save over two-thirds of the cost of your solar system by building and installing it yourself. Most self-built systems are the air-type; they are easier to construct because there are fewer leaking, freezing, and corrosion problems.

It always pays to be an educated consumer and this is particularly important if you choose to build your own system. Solar heating systems are not complicated; however, there are many minor and major errors a novice can make. Read all you can on the subject, talk to people who have built their own systems; their experience could prove to be invaluable to you. Be well prepared before you start.

Once you have decided to use an active solar system and you know whether you want to build it yourself or have it commercially-installed there are several crucial decisions to be made:

THE COLLECTOR

The collector panel is the most sensitive and variable component of a solar heating system. When buying or fabricating a collector there are several important considerations:

- What is its cost? This is usually expressed in dollars per square foot;
- How efficient is it? i.e., how much of the available sunlight will it convert to usable heat?

- How difficult will it be to install?
- How durable and how easy is it to repair should something go wrong?
- Is it protected from freezing, over-heating, snowloads or corrosion?
- What is its expected lifetime?

In assessing the above factors, it is useful to look at the various components of the collector:

Glazing

The transparent or translucent covering of the solar collector acts as a heat trap (greenhouse effect) by preventing the wind and convection currents from carrying the heat away. Two cover-plates are required in most Canadian locations, but one may be sufficient, especially if the absorber has a selective surface. The glazing (either glass, fibreglass or plastic) should maintain its transmission characteristics over time. It should also be strong and easy to work with. Glass with low iron content, fibre-reinforced plastics like Kalwall, and plastic film such as Tedlar, all have their advantages and disadvantages. Read the manufacturers' literature and guarantees very carefully.

Absorber

The absorber plate converts solar radiation to heat. A good absorber plate absorbs most of the radiation, provides good heat transfer (to the transfer fluid) and is non-

corrosive and durable. Selective surfaces give plates high absorption and inhibit the re-radiation of heat energy. Black chrome and black nickel are two selective surfaces that can be electroplated onto an absorber plate. While some absorbers are made from plastic, rubber or screening, most are copper, steel, or aluminum. Copper is the most expensive but it is the best for heat transfer and is most resistant to corrosion. Aluminum and steel corrode more easily in water systems so a corrosion inhibiter must be added to the liquid.

Transfer fluid

The advantages of air over water as a heat transfer fluid have been discussed elsewhere. The following discussion will apply to water-type systems only. To protect the collector pipes from winter freezing, the water should drain down or should contain an antifreeze solution. Additives that inhibit corrosion and the growth of slime are also available. Liquid transfer agents with a very low freezing point and a very high boiling point have been developed. They also inhibit corrosion.

If you don't want to invest money now in a solar heating system, there are still certain things that you can do to incorporate solar energy into your current or future home at little or no additional cost. As many people will substantiate, passive solar heating is an effective and inexpensive concept. By incorporating passive features in your house design, you will receive free heat and light. Similarly, a house can be designed and built so that a solar system can be added some time in the future. Features such as orientation, roof slope, storage area and piping connections should be considered in the design of new houses. This foresight will minimize the expense of adding a solar system in the future. A good house should last a hundred years or longer; probably well beyond the end of the petroleum era. Houses, which for their lifetimes are stuck with an outdated mode of heating such as oil or electricity, will become more and more of a burden to maintain. Already, in some parts of the country where electricity costs are over 5¢ per kwh, the heating bills are greater than the mortgage payments.

CONSUMERS GUIDE TO WIND

Many Canadians envisage a future in which they will choose to be, or may even have to be, independent of utilities. One of the many likely alternatives to hydro or nuclear energy is wind-generated electricity. Judging purely by the wind-generators in use across Canada, their immediate and widespread application is not yet feasible. However, interest is continuing to grow and more and more people are exploring and experimenting with wind-generated electricity. Nevertheless before this interest becomes widespread, some basic questions must be asked. When is it cost efficient to use electric energy from the wind? What are the factors you should consider before purchasing a windplant? What should you look for in selecting the right equipment? Will a wind-generator system meet the electrical needs of your home? What kind of system do you need? This report may not be able to provide all the answers to these questions, but it will help you to formulate the right questions to ask others.

Many factors may affect your original decision to investigate wind-generated electricity. These are, however, only two basic factors that determine the feasibility of a windplant:

- the site conditions;
- the cost effectiveness.

The amount of wind-power a specific site can expect is critical. Whole regions that appear to have insufficient wind-power potential may contain sites that are appropriate.

The economic efficiency of a power system is one of the most basic questions facing a prospective builder. Today there are only two or three situations where a wind-generator is economically feasible:

- for sites located far from the grid;
- as an alternate to a diesel run generator;
- as a source of independent guaranteed power.

However, there are current developments in the technology of wind that may alter the economic balance:

- the increasing cost of utility-supplied electricity;
- the potential decrease in costs (with mass decentralized production) of wind machinery.
- the use of synchronous inverters.

Besides attempting to answer some of your questions regarding economics and site feasibility, this section will outline factors to be considered when determining your power requirements and choosing the correct hardware:

Site Evaluation

Choosing a site is perhaps the most important technical decision you will have to make. Begin by checking the average windspeed in your area. Generally, the Maritimes,

Québec, Northern Ontario, the Prairie Provinces and Northern Vancouver Island have good wind-speed averages (over 10 mph).

Preliminary Site Investigation

There are varying estimates on the required average wind-speed for a cost effective plant. As the cost of fuel and electricity increase and wind technology improves, these estimates may change. It is safe to say that sites with an average windspeed of 10mph for two or three days per week have suitable wind energy potential. You should be aware that winds may vary according to the seasons, so take a careful look at the yearly average and the seasonal differences that occur in your locality. The second step is to make a detailed investigation of your specific site.

Specific Site Investigation

The power potential of your specific site may be greater or less than that of the general area. Two principles are useful to consider when choosing your site:

Avoid turbulence arising from any obstacles or landforms. It may cause blade shearing and reduced windpower. A good rule of thumb is to place the windplant 30 feet higher than any obstacles within a 300-foot radius. Windspeed (hence windpower) increases with the height above the earth's surface. Many manuals chart the

relation of windspeed to height. There is no accurate way to estimate the number of kilowatt hours available from the wind over any given period. To match erratic windspeeds with a variable power demand is an impossible task. One can only do a rough calculation over a period of time. To estimate the power available from a specific site, there are three methods you could use:

- The most sophisticated (and expensive) is to use a Wind Energy Monitor. This is a machine which automatically converts windspeed data to the number of kilowatt hours available from a particular site. It is determined by using a chosen windplant at a given theoretical height and is taken over the period tested.
- The most common(and recommended) method is the 'spot check' which compares data taken from intermittent site specific tests, with wind data from weather stations in the area. The tests can be made with a low cost wind odometer. The weather station data is adjusted to the site data, taking into account the chosen height of the windplant. Manufacturers' information for the selected windplant is used to forecast the amount of power the site can produce. However, this figure should be reduced to allow for system inefficiencies. For example, a battery equipped d.c. system is only 60 per cent efficient.
- Sometimes only the average windspeed data for the site is measured. This information is calculated from intermittent spot checks and may be applied to the specifications given by manufacturers. This method

is the least reliable.

ESTIMATING POWER REQUIREMENTS

Estimating your monthly power consumption is not a difficult task. Most manuals that describe wind technology will provide lists of appliances and their rate of electricity consumption (based on average usage). The real task which requires careful consideration is in the selection of your electrical devices according to your desired lifestyle. This means deciding on the number and types of appliances you wish to operate as well as the times of operation. This defines your level of consumption. In many cases, by simply using your applicances wisely, you can reduce your monthly power consumption. For instance, in Ian Hornby's book, Wind Power, written for Pollution Probe, Ottawa, it is shown that by eliminating certain appliances and replacing others with more conserving versions (such as an oven with a microwave oven), the energy consumption of a standard house can be reduced by nearly 40 per cent.

By practising conservation most homeowners can realize substantial savings on wind systems by eliminating or reducing expensive inverters or by buying a smaller capacity windplant. For demand calculations you must take into account the peak demand of all a.c.-appliances. This is because the start-up current required for a.c. induction motors is much greater than the actual operating current. The peak load, however, can be both lowered

and levelled out by using d.c. appliances, where practical and convenient, by installing load sequencers to prevent appliances from coming on simultaneously, and by chossing appliances whose start-up requirements are relatively small. Houses can be wired for d.c. and most appliances are available in d.c. with the exceptions of :

- fluorescent lights (unless rewired)
- devices with transformers (e.g. televisions, stereos)
- appliances with standard induction motors (e.g. refrigerators).

The major implication in chossing to live with a wind system may be the change of lifestyle it requires; a change which requires a consciousness of our demand on power instead of having power on demand.

WINDPLANTS

System components

If the site, the economics and the power demand are feasible for wind, then you can begin to think of designing or buying a wind system. There are not many types of wind generators available commercially, making your task of finding the best system for your dollar relatively easy. To make the appropriate selection, compare the cost, output and lifetime of the system. On a wind system you will need to consider the merits and disadvantages of the size of the rotor/generator, the size of the tower and the storage capacity. Most manufacturers and distributors offer all the components needed for a complete system. It is only necessary for you, as a customer, to give full information on site

specifications and power demands for the manufacturer to provide a designed system package. However, it is certainly possible to design your own system and to buy your components separately.

Home-built windplants

A wind generator is a high technology machine which is built to withstand extreme weather conditions. It is difficult to construct an efficient and reliable wind generator from scratch, and for this reason the record of home-built windplants is not a shining one. Nevertheless, there are plans and kits available for the home construction of a windplant and many of these are quite reliable. Their major drawback is their small size and output, rendering them incapable of meeting many electrical requirements.

Commercial windplants

There are three components of a windplant that should receive careful attention and consideration:

- the low speed d.c. generator or a.c. alternator;
- the rotor or propellers;
- a governor or a blade-feathering device for controlling rotor speed.

Alternators have some advantages over generators; they operate at a lower cost and do not have brushes which have to be periodically replaced. When choosing the

rotors for your windplant, there are two major considerations: the axis orientation and the diameter.

Both horizontal and vertical-axis rotor orientations are commercially available, however, most commercial units are horizontal-axis. These require a device (usually a vane) to orient them to the wind, while the vertical-axis units have the advantage of being able to capture the wind from any direction.

The diameter of the rotor is an important consideration since the potential power output of the machine is proportional to the square of the blade diameter. Tables which indicate the power generated by a wind machine with varying rotor sizes are available in most manuals on wind energy.

Most commercially produced plants include a governor or feathering device to reduce the amount of wind captured and to retard and stabilize the speed of the propeller as the wind speed increases. There are some models which require manual control such as those that apply brakes to turn the machine out of dangerously high winds.

Choosing a windplant

Most commercial machines are sold according to a rated output in a given wind regime, e.g. 2000 watts in a 25mph wind. You should remember that the rated output gives

only a relative indication of the power potential of a particular machine, and must be compared with the specific wind regime of the site to determine the actual power it will generate.

As in the site evaluation, there is a gross preliminary method and a more refined, formal method for choosing a windplant.

As a preliminary estimate, charts of average monthly output in kwh for varying sized generators are available in most texts. This enables you to choose the approximate size you require for your windplant based on your site and energy needs.

The more formal method requires that you use manufacturers' windplant date together with your figures on site windspeed to calculate your particular monthly output and to compare the available power with that of other machines. Finally, most manufacturers or distributors are willing to interpret your site information and to recommend a windplant which suits your needs.

TOWERS

Installing a wind generator on top of a tall tower will not only reduce turbulence but will also increase the power output of the machine. According to Enertech of Vermont, 'The least expensive way to get more power from the wind is to build a high tower.'

The correct tower height will depend on the wind characteristics of the site (often determined by land forms that may either increase windspeed or cause turbulence) . However, the tower should always be at least 30 feet taller than any obstacle within a radius of 300 feet.

INSTALLATION

There are several factors you must consider when erecting your mill:

- the tower must be constructed on solid foundations;
- the manner in which you will get the mill to the top of the tower (often with a mobile crane or a davit with winch and cable);
- ensure you have the proper electrical connections:
- make sure there is lightning protection for the plant.

Often a manufacturer will ask that their field supervisor be present at the erection of the windplant to ensure a valid guarantee.

TWO SYSTEMS

There are two factors that determine the design of a wind system. The first, a remote system,is constructed where there is no commercial power available, or in cases in which the owner has chosen to be independent of it. In such cases, in addition to the windplant, the system consists of storage batteries, possibly inverters (for conversion to a.c. for some appliances) and perhaps some auxiliary power source.

The second, a utility supplemented system, is attached to and works in cooperation with the local power grid. This system consists of a synchronous inverter or converter which converts d.c. to a.c. power in a way that is acceptable to the electrical grid. Synchronous inverters provide 60 cycle 110 volt power to your home and are able to feed excess power into the public power grid.

Remote system

Most remote site power systems run d.c. current to batteries which store or provide electricity. The first rule when designing your remote system is to make sure that the battery system you use has the same voltage on the input (wind generator) side as the electrical system on the output side. Car batteries are commonly used for do-it-yourself systems, although heavy marine batteries are superior, both for their lasting qualities and their ability to charge and discharge over extended periods. These batteries are used in yachts, fork lifts and golf carts. When purchasing batteries , the best measures of value are price and the manufacturer's guarantee. Properly protected batteries should have a lifetime of up to four times the length of the guarantee. Battery storage areas should be well ventilated to prevent a build-up of explosive hydrogen gas and should be maintained at the optimum temperature of $77^{o}F$. Unless you have auxiliary power, your battery capacity should be designed to tide you over the longest windless spell of the year.

Auxiliary power may be a more economical or convenient way of ensuring a constant supply of electricity. This normally includes a 115 volt or 115/230 volt fossil fuel generator with remote start capability, a.c./d.c. rectifer and two voltage-sensing relays to monitor the voltage of the batteries.

People in remote areas sometimes begin their system by simply installing an auxiliary power unit. They then add the components of the wind system as they can afford to, until the auxiliary power system becomes the back-up for the wind generator.

Inverters are used to convert d.c. to a.c. for those appliances that require it. Inverters, however, are expensive and may cost from $1.00 to $3.00 per supplied watt (e.g. and inverter for a colour television might cost from $350 to $1050). What's more , they require up to 30 per cent of their output capacity just to run themselves. For these reasons you should carefully consider your inverter capacity needs before installing.

Utility-supplemented system

The initial cost of a system which comprises only a synchronous inverter is about two-thirds of a remote system, mainly because it eliminates the need for batteries or other inverters. This type of system is

new and there are unresolved economic questions concerning the rate structure that the utilities will apply (e.g. will they buy back the electricity at the same value or less?; how much less?) Some provincial Hydro authorities seem to be amenable to cooperating with individuals regarding the establishment of rate structure and safe installation. However, you must check with your own provincial or municipality utility before installing a synchronous inverter. The question of savings from a synchronous inverter is an academic one, since the device is still at an experimental stage in Canada.

ECONOMICS

When considering the initial capital cost of your wind system, you should not forget the hidden freight, installation and possible duty charges. This can add thousands of dollars to the cost you anticipated. The cost effectiveness of your system can depend on three factors:

- the amount of power your system can produce given your site conditions;
- the current and anticipated costs of power from conventional utilities or, for remote sites, fossil fuel generators;
- the initial capital cost of bringing power lines to a semi-remote site.

There are only eight or nine different makes of wind generators commercially available in Canada today. Costs range from $600, for a 200-watt machine capable of running a few lights and a small pump, to $12,000 for a 6000-watt

machine including a tower and battery set which is capable of running a conventional home.

John and Donna Ramsey from Prince Edward Island have been living autonomously on wind power since 1971. They estimate that they consume about one-half to two-thirds of the electricity of a conventional home. Their system includes a tower and batteries and cost about $7200 without installation (in 1977 dollars).

Wind systems are not for everyone. They are best suited to windy sites where commercial power is not available or the costs of electricity are unusually high.

CONSUMER GUIDE TO WOOD

When properly managed, wood is a renewable form of solar energy. The sun's energy is stored in trees by the process of photosynthesis and released by combustion. It's ironic that in this technological age wood heating is now considered the way of the future. More and more Canadians are discovering the ecnomic advantages of heating with wood, particularly in those areas where there is a pentiful supply close at hand. This is largely because conventional energy costs are soaring and new woodstoves and frunaces that are both convenient and efficient are available at reasonable cost. Today, if you have ready access to a woodlot, it is the cheapest fuel available.

It should be noted,however, that the cost of a cord of wood varies considerably. In a large city wood can cost over $100 a cord. If you have to buy wood, as opposed to harvesting it from your own woodlot, there are certain rules which should be followed:

- if you intend using it within six months, buy seasoned wood. Green or moist wood is difficult to ignite and keep burning and the efficiency of the heating unit is reduced. Green wood is usually cheaper, but buy it only if you can let it air dry for at least nine months;
- wood is sold by volume; a cord measures 4ft by 8ft by 4ft deep. Denser woods (the hardwoods) have a higher energy content per unit volume than lighter woods. This means that they are better for both heat content and their ability to sustain a fire.
- the more work you put into gathering wood, the cheaper it will be (and the healthier you will become). It

can cost a lot to have a cord of seasoned, split hardwood delivered and stacked. How much involvement you have with this process is a question of time and opportunity.

- wood contains a lot of energy when used properly. The days of a farmhouse burning 15 or 20 cords a winter are gone. A well-insulated home, using a modern efficient wood stove or fireplace, should use only 3 to 6 cords of wood.

Today wood is often used as an auxiliary heat source. By using wood in conjunction with another source of heat energy, a balance between the convenience of other fuels and the economy of wood can be achieved. The majority of solar houses in Canada use wood as the principle auxiliary fuel.

Concerns

A number of concerns people have held about heating with wood are no longer valid or are less applicable than they were in the days when old wood stoves were used. Any system which burns fuel for heat is a potential fire hazard. The correct installation and use of wood heating units minimize this problem. However, caution is always advised. When installed properly, there is little fire hazard with an air-tight wood stove.

The formation of creosote in the flue can be a porblem with wood combustion. When the temperature of the fire drops, the partially burned gases enter the chimney and condense

in the cold flue to form creosote. It is flammable and if ignited a chimney fire could spread to the house. However, with a sound chimney (masonry or insulated metal flue), there is little to worry about.

An additional concern with wood heating is the pollution that results from the incomplete burning of gases and particles contained in smoke. Wood is a clean fuel which is virtually sulphur free and it does not aggravate suplhur dioxide pollution. From a global perspective, the combustion of wood is equivalent to the slow oxidation process that naturally occurs in forests through the decomposition of trees. This means that the net carbon dioxide output is no greater in the accelerated combustion process, though it is more concentrated.

The biggest drawback for most people heating with wood, is its inconvenience. To heat with it requires cutting and the splitting of logs, and the fire must be constantly maintained. It can be messy owing to the ashes and wood chips. Also, wood is bulky and a heavy fuel in relation to its heat content, and adequate storage space must be allowed.

Modern efficient wood stoves reduce these inconveniences considerably (as discussed below). However, eventually it does come down to a question of lifestyle; whether you will tolerate the inconveniences for the financial savings,

the economy and (some would swear), the comfort of heating with wood. Many wood enthusiasts do not see the inconveniences as concerns but, instead, enjoy the chores and physical activity involved.

MODERN EFFICIENT HEATING UNITS

Old woodstoves generally are not air-tight and make no provision for burning the volatile gases. This means that the combustion of wood is incomplete and the heat efficiency is therefore reduced. Modern heating units are preferable because they are virtually air-tight. Primary air is admitted directly into the fuel bed and there is provision for secondary air above the wood to burn the volatile gases given off during the combustion process. This complete combustion provides long burning fires, constant temperatures and good draft control. No more air than is necessary to maintain combustion enters the firebox, thus reducing the amount of hot air that escapes up the flue.

Some stoves have thermostats which automatically control the amount of air entering the firebox. Scandinavian stoves have an interior baffle system which permits good temperature control without a thermostat. In such cases heat transfer is maxmimized.

A complete air-tight stove can more than double the efficiency of wood stoves. This means that only half the amount of wood is required to provide the same heat, thus increasing the

the convenience and economy of heating with wood. Fires can burn for 12 or more hours so that the stove has to be tended for two, or at most three, times a day. The same fire can be kept burning all winter, thus eliminating the need to re-start the fire every morning.

There are now thermostat-controlled wood-burning furnaces available which have similar features to efficient woodstoves, i.e. they are air-tight and there is provision for primary and secondary air. These furnaces connect directly to a conventional forced hot-air distribution system in the house.

There are also combination furnaces available which burn either wood or fossil fuel such as oil, in seperate chambers, switching automatically when the wood is completely burned. This means there are no freezing problems if the fire goes out or is left untended.

FIREPLACES

Generally fireplaces are extremely inefficient. About 90 per cent of the heat produced goes up the chimney. In many cases, the fireplace actually contributed to a net heat loss from the house by drawing warm air from the room up the chimney.

An energy efficient fireplace (like the original Franklin) utilizes outside air for combustion and heat circulation. This minimizes the amount of warm air from the house that is drawn up the chimney and the quantity of cold air infiltrating the house. The addition of air-tight doors to the fireplace greatly increases the efficiency of combustion and reduces the amount of warm air drawn out of the room. The damper should be closed when not in use and should be at its narrowest setting without making the fireplace smoke. Also, maximum direct radiation enters the room through fireplaces which are shallow, tall and wide, since this directs the fire into the room as much as possible. Heatilator units, which allow room air to convect around the firebox and back into the room, add to the heating capacity of a fireplace.

INSTALLATION

If you have elected to heat your home with wood, you will have to decide which rooms are to be heated by the stove/furnace and how the heat will be distributed to those rooms. Heat will travel up stairwells or from room to room if there is an air passage. Vents of at least 2 square feet at the ceiling and the floor will aid heat circulation. The heating unit must be accessible; it is impractical and inconvenient to have to haul the wood long distances from the storage shed and through the house.

CHIMNEYS

A good chimney for your fireplace, stove or furnace is crucial. Its main functions are to carry the undesirable combustion products (smoke etc.) out of the house and to supply the draft or pressure forces to feed air to the fire. You will probably have to choose between a masonry chimney and one of prefabricated metal. A masonry chimney is more difficult to install but is likely to be more durable. It has a large heat storage capacity that will enable it to radiate heat into the house long after the fire has subsided. Double-walled metal chimneys, on the other hand are usually less expensive and easier to install. However, they are likely to be less durable than masonry chimneys owing to the corrosion caused by the chemicals in the exhaust from the stove. If you choose to unstall a metal chimney, it is wise to inspect it frequently for decay.

PURCHASING YOUR HEAT UNIT

After making the decision to heat with wood, there are several factors to consider before purchasing your fireplace, stove or furnace. First, you should look at the quality of construction of the heating unit. A well-made cast iron stove is likely to last a long time. If you choose a steel stove you should consider the thickness of the metal and the quality of the welds. The welds should show no porosity and should be slightly convex. Compare the prices of well-known commercial products with any

locally-manufactured heating units. Sometimes the quality of the local units will be as good or better than the known makes, while the cost can be considerably less. Check the weight of the materials used in its construction when making your decision. For stoves or furnaces, look for air-tightness and temperature control as well as provisions for primary and secondary air. These features make for an efficient heating unit that is able to recover most of the heat produced. This adds to the convenience and economy of heating with wood, since the quantity required is greatly reduced.

Some wood stoves are very attractive and make a pleasant addition to the furnishings in a home. In particular, the old-style cast iron stoves beautifully combine form and function in their construction. They come in many different shapes and sizes and with a wide range of energy-efficient units available today, there should be something to suit your taste.

Lastly, enjoy your wood stove. Wood-burning enthusiasts (and their numbers are growing) swear by wood heating; they enjoy the comfort, warmth and security of radiant heat. The old adage from the Maritimes is still valid today: 'There's no heat like wood heat.'

ECONOMICS

As discussed earlier, the economic viability of a renewable energy technology should not be the only criterion used to determine its acceptability. The systems can be, and often are, justified on social, environmental or political grounds.

However, to examine renewable energy solely on economic considerations, wood heating is easily the cheapest fuel source available today (providing there is access to a wood-lot).

Similarly, in remote areas off the power grid, wind-generated electricity can compete favourably with other electrical generating systems.

Solar space heating is on the verge of becoming economical in the traditional sense. Most of the do-it-yourself systems will pay for themselves within a few years, while many commercially-installed systems will offer a pay-back within the expected lifetime of the system.

Arriving at an estimate of the pay-back period of renewable energy systems involves some very complex considerations. Unlike conventional energy sources, there are large capital outlays at the beinning, with relatively low yearly costs for operation and maintenance. This is complicated, because you

are dealing with emerging technologies based on variables that have not been fully explored, and energy prices which are affected by government (both here and abroad).

Wood burning technologies are generally much better understood than solar or wind and more closely approximate the conventional systems. There is the initial cost for the stove or furnace, followed by the yearly cost of fuel (wood). The differences are that wood is a renewable resource and generally, wood-burning is not environmentally disruptive (although it has that potential) and can be cheaper than oil or electricity.

Solar heating and wind generation are different from conventional energy systems in that the consumer must pay a high initial cost, but the operating costs are very low. Life-cycle costing is a means of comparing all the expenses of a system with all the savings. The annual costs of one system can be compared with those of another (the conventional system) over the expected lifetime of both systems.

With a renewable energy system the costs include:

- initial capital costs plus interest on borrowed money;
- annual operation and maintenance costs;
- any extra insurance or taxes, such as increased property assessment.

The savings associated with a solar, wind or wood system include:

- annual fuel savings;
- potential appreciation; as oil or electricity becomes

more expensive a solar system will be worth more;

- a hedge against general inflation and escalting fuel costs.

Some of these variables such as intial capital costs (installed) and interest rates are fairly easy to calculate. Others, such as operating and maintenance costs and annual fuel savings, are more difficult. The annual fuel savings depend on two major factors: the usuable energy supplied by the system and the cost of alternatives. The energy supplied by a system will depend on :

- the size of the system;
- the efficiency of the system;
- climatic data of the location, such as insolation, degree-days, wind regime;
- the energy demand (for space heat or electricity);
- the expected lifetime of the system as determined by factors such as freeze and corrosion - tolerance and the materials used.

It would be helpful if the costs of alternative fuels such as oil, gas and electricity could be estimated over the lifetime of the system. Unfortunately such calculations are difficult to make since fuel costs are increasing each year and with general inflation it is virtually impossible to predict future prices. The best that can be done is to make assumptions of future price escalation, say, ten per cent per year.

If the cost of a solar heating system is carried by a long-term mortgage there will be a constant payment each year. For example: a 25 year mortgage on a solar-heating system can result in a yearly payment of $700. It will probably be cheaper the first year to supply an equivalent amount of heat by oil or electricity. However, this will change as the yearly cost of conventional fuel keeps increasing while the solar costs remain constant.

If the electrical-heating costs are $500 the first year (with a 10 per cent yearly increase), by the fifth year it will cost $732, more than the solar mortgage (in this example). By the tenth year the yearly cost is almost $1200. Similarly, if it costs $350 to supply the same energy by oil the first year, it will cost $825 the tenth year. By the twentieth year oil costs would be over $2000.

The critical decision to be made is how much you are prepared to spend now in order to realize savings in the future. Various factors can affect this picture. Conventional energy costs in some regions of Canada are twice those in other parts. The cost of a solar system will vary as will the amount of energy it supplies (and therefore the amount of conventional energy it displaces). All these considerations must be carefully weighed.

Most people do not build or buy a house with a view to living there for twenty-five years and they are therefore concerned about the depreciation and resale value of a solar house.

A solar (or wind) system will depreciate over time as its useful life decreases. However, this will be counteracted by the fact that the costs of the alternatives are rising each year. In the above example, the new owner who takes over the solar system five years after it was installed will save on fuel costs in his/her f rst year when compared to electrical heating. Therefore, the solar system (and the mortgage) should be considered a good investment.

Sometime in the future, mortgages for solar-heating systems may be subsidized. Providing mortgages at half the going interest rate, for example, can reduce a $700 yearly payment to $450. Under such a scheme solar energy becomes much more feasible.

In the meantime there are many questions to be grappled with: are oil, gas and electricity costs going to rise by 10 per cent each year? by 5 per cent?, 20 per cent? What will inflation do to prices? How much are you willing to invest now to save money in the future? Are the costs of renewable energy systems going to come down? How much is it worth to you to be wholly, or partly independent of the large energy corporations? How do you view your responsibility vis-a-vis the environmental damage which is associated with conventional energy systems? What do we owe our children and our grandchildren?

How you interpret these issues and respond to the questions they raise is the challenge of your future.

GLOSSARY

ABSORBER
The blackened surface of a collector which absorbs solar radiation and converts it to heat energy. A flat black paint is a good absorber; it absorbs 90 per cent of the short wave radiation. It is also a good emitter of long wave (heat) radiation. See SELECTIVE SURFACE. The absorber surface can be made from various materials, ranging from flat copper sheeting to treated glass. The ability to transfer heat and to resist corrosion are two important features of the absorber.

ABSORTIVITY
The fraction of energy striking a surface that becomes absorbed as heat. Absortivity is usually about 0.9 for a flat black surface.

A.C.
Alternating current. The type of electric current which is used by most modern appliances. It has been developed by the utilities because it transmits more efficiently than D.C. (direct current) power.

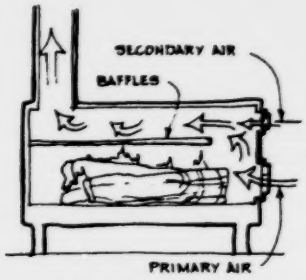
ACTIVE SYSTEM
A solar heating system which requires outside energy such as pumps or fans, in order to operate.

AEROGENERATOR
See WIND GENERATOR.

AIR DRIED
The natural drying of wood that reduces the moisture content to below 20 per cent. Dry wood will burn more efficiently since much energy is spent boiling off water in green or moist wood, resulting in a slow and inefficient fire. Wood should be seasoned over a period of 9 months to a year. A pound of dried wood contains about 7100 BTU.

AIR SYSTEM
A solar collection system which uses air as the transport medium. Storage of heat energy is usually in a rock-bed or an insulated bin housing many small water containers. An air system has advantages over a water-type system; it does not freeze or corrode and leakage is not as serious a problem.

AIR TIGHT
Refers to an efficient wood burner construction in which the air intake can be controlled so that no more air enters the burner and goes up the chimney than is necessary for efficient combustion. A constant temperature is maintained by keeping the fire burning steadily. The efficiency is increased, allowing the stove to hold a fire for 12 hours or more.



WOOD STOVE

ALTITUDE
The distance from the horizon to the sun measured in degrees. At 44 degrees latitude at solar noon, the sun rises to an altitude of only 22½ degrees on December 31 and to a high of 69½ degrees June 21.

ALTERNATOR
A machine which converts mechanical power (e.g. turning wind-generator blades) into a.c. electricity.

AMBIENT TEMPERATURE
Refers to the temperature outside a dwelling.

AMP-HOUR
A unit of measurement of battery capacity. It is defined by the quantity of electricity passing a point in a circuit in one hour, with a steady current of one ampere (one coulomb/sec).

AZIMUTH
The angular distance between the point on the horizon which the sun is directly above and true south.

BAFFLES
A configuration, often found inside efficient Scandinavian wood stoves, which controls the flow direction of combustion air or flue gases. A baffle in the upper part of the firebox directs the draft in an S-shaped pattern causing the logs to burn evenly from front to back while maintaining a constant temperature.

BIOMASS
The layer of organic (living or once living) material on the earth. It includes all vegetation, animals and man. The key to the chain of biomass material is the photosynthesis process which converts sunlight into usable energy.

BRUSHES
Conductors within a generator which allow current to flow between the stationary and moving parts.

BTU
British Thermal Unit. A measurement of energy, defined as the amount of energy required to change one pound of water one degree F. A match contains approximately 1 BTU and a gallon of fuel oil contains approximately 140,000 BTU. A well-insulated house in the Ottawa region may require 90 million BTU for space heating over the year.

BTU/DD
BTU per degree-day. A unit of measurement of heat demand of a house. See also DEGREE-DAYS.

CFM
Cubic feet per minute. Refers to the capacity of a fan for moving air.

CLOSED LOOP
A system where the heat transfer fluid from the solar collector is separated from the storage via a heat exchanger. A closed-loop system is used when corrosion inhibitors or anti-freeze solutions are circulated through the collectors.

CLIVUS MULTRUM
The name brand of a Swedish composting toilet which is commonly used for decomposing waste. 'Clivus toilet' generally refers to any composting toilet that operates on the principle of a Clivus Multrum.

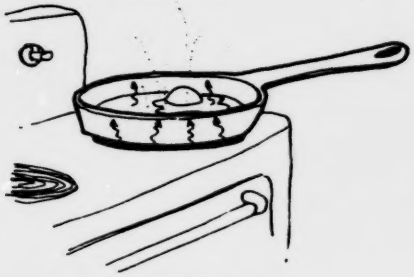
COLLECTOR
A device which absorbs solar radiation and converts it to heat energy. There are a great many different types of collectors. See FLAT-PLATE COLLECTOR, EVACUATED TUBE.

COLLECTOR AREA
The area of a collector which traps the sun. A rule of thumb in calculating the required collector area has been to use one half of the floor area that is to be heated. However, a more important parameter is a building's heat loss. Well-insulated houses require a collector area of only one quarter to one third of the floor area to supply 40-70 per cent of the total house heating load, depending on the house and its location.

COMBINATION FURNACE
A furnace which can efficiently burn wood or a fossil fuel such as oil. It offers the choice between the economy of wood heating and the convenience of fossil fuels.

COMPOSTING TOILET
An aerobic digestor for human and kitchen wastes. The waste decomposes to a compost material which is under 10 per cent by volume of the original. Composting toilets do not require any water source. The CLIVUS MULTRUM type does not require any outside energy.

CONDUCTION
The transfer of heat energy along a body, or from one object to another by direct contact.

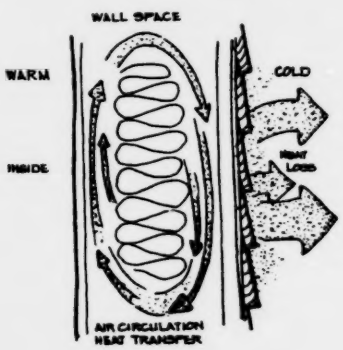


HEAT BY CONDUCTION

CONIFEROUS
The type of trees which retain their leaves (needles) throughout the year. Usually a softwood.

PINE

CONVECTION
Heat transfer mode requiring the motion of fluids (air or water) rather than direct contact.

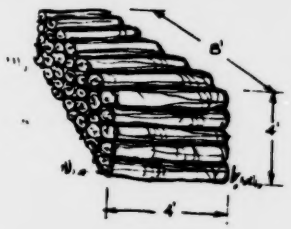


CONVECTION

C.O.P.
Co_efficient of performance. Refers to a measuring standard of a HEAT PUMP. A C.O.P. of 2.5 means that for every unit of energy input into the system, 2.5 units of heat is output.

CORD

A measurement unit (by volume) of wood. A full cord measures 4ft by 8ft by 4ft while a face cord measures 4ft by 8ft and is usually about 16in. deep. A cord of wood weighs from 2200 to 4400 lbs , depending on density; the hardwoods (maple, oak, birch) are the heaviest. The fuel content of a single cord of air-dried wood ranges up to 31 million BTU, and averages about 22 million BTU for hardwood. The price of a cord varies widely across Canada, ranging from $30 to $130 per cord, depending on proximity to wood source, transportation costs, etc. A well-insulated house heated solely with wood may require 3 to 5 cords per year.



CORD

CORROSION

The pitting or deterioration of materials. Corrosion can occur when a sensitive material such as aluminum is used for the absorber plate and fluid transfer ducts without the use of an anti-corrosive agent.

CREOSOTE

The tar-like deposits in a flue created by improper burning in a wood stove. It is formed when the fire cools to a point at which combustion is incomplete. The partially burned gases and water vapour condense in the chimney and when the water re-evaporates solid creosote is left. Creosote is highly flammable and can be a serious problem if an uninsulated or corroded flue is used.

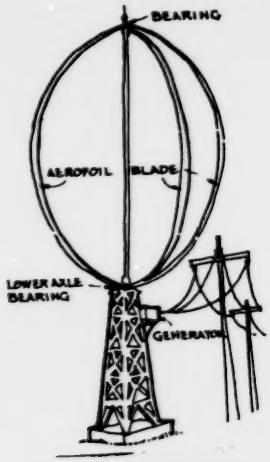
CUT-IN-SPEED

The minimum speed which activates a wind machine as the wind speed increases.

DAMPER

A valve for controlling air flow.

DARRIEUS ROTOR
A vertical axis wind generator which resembles a huge hoop or 'egg beater'. Recently re-developed by the National Research Council in Ottawa, these rotors are efficient and could be manufactured at a low cost. The rotor is not self-starting, but once in motion will accept wind coming from all directions.



DARRIEUS ROTOR

D.C.
Direct current. Batteries store direct current electricity. See A.C.

DECIDUOUS
The type of trees which lose their leaves in the winter. Generally hardwoods.

OAK

DELTA T (Δ T)
A change in temperature. It is used to measure the temperature change in a body, or the temperature difference between two bodies.

DEGREE-DAYS (DD)
Generally refers to the total number of Fahrenheit-degree variations below 65°F, of the daily mean outdoor temperatures throughout the year. A day that averages 40°F totals 15 DD. Ottawa totals 8500 DD throughout the year.

DESIGN HEAT LOAD
A measurement of the total heat loss of a structure in conditions close to the lowest temperatures which are likely to occur.

DIFFERENTIAL THERMOSTAT
Usually a double sensor thermostat which automatically turns the solar system on and off. When the sensor in the collector is at a higher temperature than the sensor in the storage, the differential thermostat will start the pump or fan and useful heat is collected. When the collector temperature drops below the storage temperature, the system shuts down.

DIFFUSE RADIATION
Solar radiation from the entire sky that has been scattered by water vapour and dust in the atmosphere. It may provide up to 60 per cent of the total insolation during the winter months in Canada.

DIRECT RADIATION
Solar radiation that comes directly from the sun on a clear day. Direct radiation in Canada on a horizontal surface ranges from 60 per cent of the total insolation to a low of 40 per cent during the winter months.

DISTRIBUTION
The system that distributes the collected/stored heat throughout a building via a heat exchanger. Water pipes with baseboard radiators and forced air ducts are two common methods of heat distribution.

DRAIN DOWN
A system in which the solar collectors are automatically drained of the circulating water when the system is not collecting heat energy. By removing all the water, freezing and the resulting damage to the pipes is prevented.

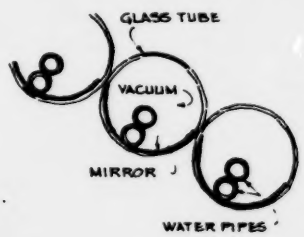
EFFICIENCY
Generally refers to the percentage of total available energy that is actually collected, transferred, stored or used; e.g., a solar collector which operates at 50 per cent efficiency collects and transfers half the energy of the radiation striking the collector.

EMISSIVITY
The fraction of energy which is re-radiated as longwave (thermal) radiation by an absorber plate. Generally, a good absorber is also a good emitter (0.9). This re-radiation of thermal energy is a significant factor in the heat loss of a collector. Selective surfaces reduce the emissivity to about 0.1, resulting in greater efficiency.

ENERGY
The ability to do work. It takes many forms; i.e. potential energy (water before it goes over a falls), radiant energy (sunlight) and mechanical energy (a moving object). Energy always flows in one direction, degrading ultimately to heat (entropy). It may be discussed in terms of high grade energy (i.e. electricity) or low grade energy (heat).

EUTECTIC SALTS
A family of materials that absorb heat by melting at low temperatures. They store the heat energy in the form of latent heat of fusion. Glauber's salt (sodium sulphate decahydrate $Na_2SO_410H_2O$) is a common eutectic salt which melts at 90^oF and stores 104 BTU per pound.

EVACUATED TUBE
A type of flat plate collector on which the absorber surface is surrounded by a vacuum. This eliminates heat loss by conduction and convection. It can achieve relatively high efficiencies, especially under extreme conditions such as low insolation levels, or very low ambient temperatures.

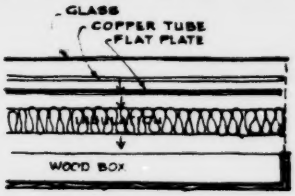


EVACUATED TUBES

FEATHERING
The rotating action of the propellor blades of a wind generator to reduce the amount of wind captured. This generally operates automatically in high winds to prevent the generator from burning out.

FENESTRATION
The arrangement of windows in a building.

FLAT PLATE COLLECTOR
The family name for solar collectors which accept diffuse (sky) radiation as well as direct radiation without the use of focusing or concentrating devices.



FLAT PLATE COLLECTOR

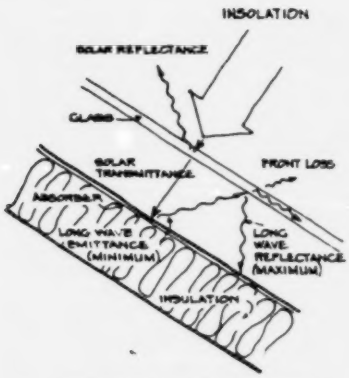
FLUID TRANSFER
The medium which removes the heat from the solar collector and carries it to storage or distribution. Air and water are two common fluid transfer agents.

FREEZING
The process of hardening due to cold. May happen to exposed collectors during winter. The fluid transfer medium must be prevented from freezing in the collectors since the pipes would be severely damaged. Liquid type collectors solve the problem either by draining down when not in use or by using an anti-freeze agent in a closed loop system. Air systems do not require freeze protection.

GENERATOR
A machine which converts mechanical power (e.g. turning wind-generator blades) into d.c. electricity.

GLAZING
A transparent or translucent covering. Refers to both windows and collector coverings. Double-glazed refers to two layers of covering as in thermopane or storm windows. On a collector, glazing acts as a heat trap by allowing the sunlight to penetrate while retaining the heat (this is referred to as the GREENHOUSE EFFECT). Collectors can be single or double-glazed with glass, plastic or fibreglass.

GREENHOUSE EFFECT
The property of glass and other glazing material that permits transmission of solar radiation (short wave radiation), but is opaque to long-wave (thermal) radiation. The interior of a car in the direct sun exhibits this phenomenon and acts as a heat trap.



GREENHOUSE EFFECT

GREY WATER
Refers to the waste water from all the drains such as baths and sinks. Generally, grey water requires treatment before it is released to the environment. Toilet water is sometimes referred to as black water.

GRID
The network of electrical systems across the country.

GOVERNOR
A device on the hub of a wind generator that retards the speed of the propellor as the wind speed increases. It eventually stabilizes the propellor at a maximum speed and prevents the generator from burning out.

HARDWOOD
A wood with great density. The denser the wood, the more energy per unit volume. Common hardwoods include oak, birch, maple and elm.

HEADER
The pipe running at either end of a solar collector which distributes the heat transfer fluid to, or collects it from the collector.

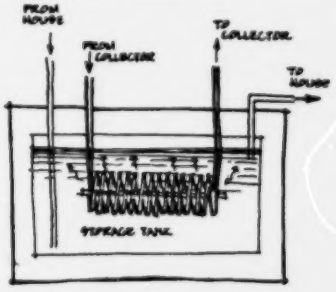
HEAT CAPACITY
A measurement defining the amount of heat required to raise one cubic foot of material one Fahrenheit degree. Specific heat is heat capacity measured in BTU. In a general sense, heat capacity refers to the ability of a material to store heat.

HEAT DEMAND

The amount of heat necessary to maintain a house at a constant temperature under given outside conditions. It is often expressed as the number of BTU required per degree-day.

HEAT EXCHANGER

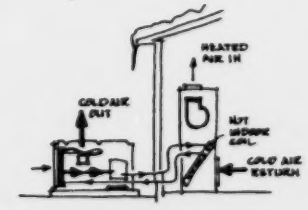
Any device which will transfer heat from one fluid to another. It can work in many modes: air-to-air, air-to-water or water-to-water (such as a copper coil in a hot water tank).



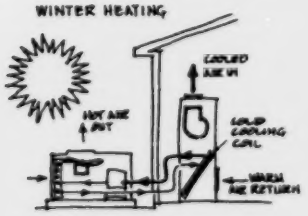
HEAT EXCHANGER

HEAT PUMP

A mechanical device for moving heat from one medium to another. It extracts heat energy from a low grade source (such as winter air) and pumps it into a higher grade heat sink (such as a building). This means that for each unit of electrical energy used to operate the compressor, a heat pump can create two or more units of heat energy. Heat pumps can be used alone as efficient electrical heaters or in combination with a solar heating system. This may be used to extract heat from storage which is at temperatures below those that are normally useful. Heat pumps may operate in many modes: water-to-air, air-to-air, ground-to-air. A refrigerator is an air-to-air heat pump. A heat pump can be reversed to cool a building by pumping the internal heat to the outside.



WINTER HEATING



SUMMER COOLING

HEAT PUMP

HEAT STORAGE
An insulated container in which energy collected by a solar system can be held for use when the sun is not shining or during extremely cold weather. The heat may be stored in a variety of media including water, rock-beds, paraffin wax or eutectic salts.

HORIZONTAL AXIS
A wind machine where the axis of rotation of the shaft is horizontal. Typical examples include the Dutch multi-blade windmills and the modern 3-bladed wind generator. This type of mill must rotate to face the direction of the wind.

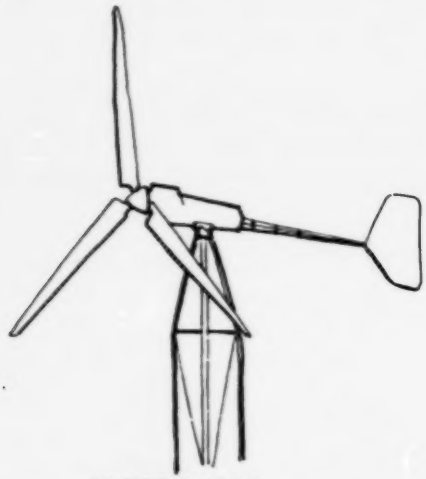
INFILTRATION
The movement of air from the outside into a house via cracks in the walls, roof, doors and windows. It accounts for a large percentage of the heat loss of a house.

INSOLATION
The total solar radiation striking any exposed surface. Insolation generally has three components: direct radiation, diffuse radiation and reflected radiation. Canada receives on a horizontal surface, a yearly average insolation of 1010 BTU/ft^2/day, or 150 watts/m^2 on a 24-hour daily average. The total insolation received by any surface will be determined by its orientation and tilt.

INSULATION
Any material which offers heat resistance and is used to retard heat flow. See R-VALUE. It takes many forms, e.g. fibreglass, polyurethane, foam, air gaps, etc.

INVERTOR
A machine which transforms direct current (d.c.) power into alternating current (a.c.) of the correct cycle and voltage. Since storage in batteries is d.c., an inverter is necessary in order to use appliances wired for a.c.

JACOB'S MILL
A brand of efficient and well constructed wind generators (generally in the 2kw range) made in the U.S. during the 1930s and 40s.



JACOBS MILL

JØTUL
Brand name of a variety of popular Norwegian wood stoves, which are airtight, baffled and very efficient.

KALWALL
Refers to both a company and the product name of a translucent material commonly used as glazing for solar collectors.

KW
Kilowatt. A measurement of power (equals 1000 watts). One kilowatt is equal to 56.9 BTU per minute or 1.341 horsepower.

KWH
Kilowatt hour. A measurement of energy equivalent to one kilowatt running for one hour. A 100-watt light bulb burns one kwh of electricity in 10 hours. One kwh equals 3413 BTU.

LATENT HEAT
Heat stored by the melting of crystalline structures without a corresponding rise in temperature. Paraffin wax and eutectic salts are two media that use the latent heat of fusion for heat storage. Two advantages are; a greater amount of heat can be stored in a smaller volume; collection and storage efficiencies are increased because there is no temperature rise.

LAW OF THE CUBE
States that the power of the wind is proportional to the cube of the wind speed. If one kw is produced by a wind generator in a 10mph wind, a 20mph wind will produce 8kw. Thus, most wind-generated electricity can be expected from 'energy winds' that blow as infrequently as 2 days a week.

LAW OF THE SQUARE
States that the power of a wind generator is proportional to the square of the diameter of the blades. If the diameter is doubled, the output will be increased four times.

LIFE-CYCLE COSTING
A method of estimating the total cost of different systems over their lifetime. It includes variables such as initial capital costs, operating costs and maintenance.

LONG TERM STORAGE
The heat storage capacity of a solar heating system that works on a long term or annual cycle. The storage is extremely large (up to 100 gallons per square foot of collector) and will supply heat during weeks or even months of cold or cloudy weather. Long term storage can provide 100 per cent solar heating.

MASONRY WALL
A brick, concrete or stone wall construction. If the masonry wall is on the inside of the insulation, it provides the house with a greater thermal mass which increases the passive storage capacity of the house.

MULTI-BLADE FAN
A type of windmill which has many blades. It is easily started and efficient at low wind speeds. However, it has a low tip-speed ratio and is not suitable for generating electricity. Wind pumps, which are still seen on many farms, are examples of this.

NET ENERGY
The total energy generated or saved once all energy expenditures have been accounted for. For example, it requires energy to mine, manufacture, transport and install insulation. However, more heat energy is saved by insulation over its lifetime than went into it. It is, therefore, a net energy saver.

NON-RENEWABLE
Finite. Energy once used that is unable to be replaced (e.g. uranium and oil at our rate of consumption are non-renewable.

OPAQUE
Does not transmit electromagnetic radiation. For example, glass is opaque to long wave radiation, but transparent to short wave radiation (greenhouse effect).

OPEN SYSTEM
A solar water system in which the storage water is circulated directly through the collectors without an intervening heat exchanger.

ORIENTATION
The compass direction a solar collector surface faces. For most locations due south is the optimum direction. In areas which experience a morning haze (such as Maritime regions), 10 degrees west of south may be better. Similarly, in regions which have a cloud build-up in the afternoon, east of south may be better able to take advantage of the morning sun. Generally, the orientation of the collectors is flexible and can vary by as much as 20 degrees east or west of south without seriously affecting performance. Houses with the wrong orientation and with serious shading problems can erect the collectors independently of the house at the optimum orientation and tilt.

OUTSIDE AIR
Air fed to the fire, heat exchanger or draft, which originates from outside the house. Some wood-burning systems use outside air to feed the fire to prevent heated room air going up the chimney. Normally, this air is replaced by cold outside air which enters the building through the cracks (see INFILTRATION) causing unpleasant draughts.

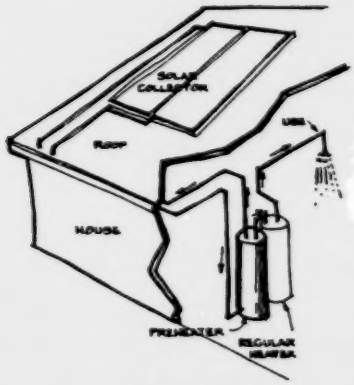
PARALLEL
Two or more equivalent systems working side by side.

PASSIVE SYSTEM
A solar heating system which requires no outside energy source such as pumps or fans in order to function. Windows are a passive solar heating system, as are Trombe wall or thermo-syphon systems. Simple features which enhance passive collection can be incorporated in house design, for example, large south-facing windows. To prevent overheating by direct solar radiation, overhangs or deciduous trees can be used to block the rays from the high summer sun while still allowing the lower winter sun to penetrate. To prevent heat loss from passive systems, such as through windows, the use of insulated or reflective curtains or shutters at night or on extremely cold or cloudy days, is possible. The use of large thermal mass in a house is another design feature which improves the operation of a passive heating system.

PLENUM
The duct running at either end of an air type solar collector which distributes the air to, or collects it from,the collector.

POWER
The amount of energy use as a function of time. A public utility refers to power as the total installed capacity of a system as opposed to the total energy actually generated.

PREHEATER
A unit which warms incoming air or water towards a desired temperature. A preheater for domestic hot water is often placed inside the storage of a solar space heating system.



SOLAR PREHEATER

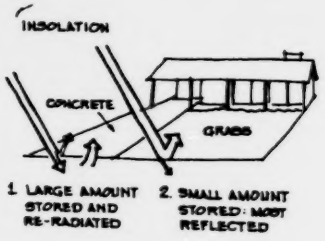
PRIMARY AIR
Air introduced into an air-tight wood stove at the base of the fire to burn the coals.

RADIANT HEAT
The electromagnetic radiation emitted by any warm object, e.g. the sun, a cook stove, a person.

RATED OUTPUT
The power generated by a wind generator at a rated wind speed chosen by the manufacturer. For example, a wind generator may be rated at 2000 watts in a 20mph wind.

RATED WIND SPEED
The lowest wind speed at which the rated output of a given wind generator is produced.

REFLECTED RADIATION
Solar radiation which strikes an exposed surface after being reflected from the ground, trees, buildings, snow, etc. Reflected radiation can play a significant role when vertical collectors are used.



REFLECTED RADIATION

RENEWABLE
Having the ability to replace itself. Renewable energy is not depleted through use, e.g. sunlight, wind and trees (if managed properly).

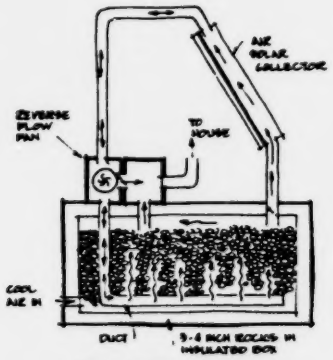
RESISTANCE COIL
A metal coil that resists the electrical flow, converting the electricity to heat energy. Used for electrical heating systems for either air or water.

RETROFIT
The addition of a solar heating system to an existing building.

REVERSE FLOW
The reversal of direction of the air flow through a rock storage system. This means that hot air enters the rock storage at the same end from which air is drawn to heat the house. This system makes use of STRATIFICATION.

RISERS
The pipes or channels on a collector surface through which the heat transfer fluid passes.

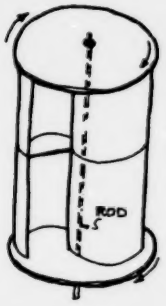
ROCK-BED STORAGE
Storage of heat in an insulated bin containing rocks. It is usually associated with an air collection system. Ideally, the rocks are round and uniform in size, usually 0.75in to 1.5in in diameter. Heated air is passed through the gaps between the rocks, thus giving up its heat. The heat is extracted from the storage by cold air which is blown through the rocks (often in a reverse direction). Rock storage holds about a third less heat per volume than water storage.



ROCK BED STORAGE

R-VALUE
Resistance value; a measurement of an insulation's resistance to heat transfer. The higher the resistance value, the less heat escapes. Three and a half inches of fibreglass insulation will have an R-value between 10 and 14. Many solar homes will have R-20 in the walls and R-30 in the ceiling, with some exceeding R-60. A poorly insulated house will range from R-2 to R-7.

SAVONIUS ROTOR
A wind machine operating on a vertical axis, with air scoops mounted off centre. It is self-starting and accepts wind from any direction. The Savonius rotor is less efficient than other wind generators because it is not able to rotate faster than the wind moving through it. It is usually used as a water pumping mill but can also be used to produce small amounts of electricity. A Savonius rotor is often made from two halves of an oil drum.



ASSEMBLED ROTOR

PLAN FOR CUTTING 45 GALLON DRUM

SAVONIUS ROTOR

SEASONED WOOD
See AIR DRIED.

SECONDARY AIR
Air introduced into an air-tight wood stove above the logs to burn the volatile gases given off by the wood during the combustion process.

SELECTIVE SURFACE
A specially treated surface of an absorber plate which has high absortivity but low emissivity. Selective surfaces such as black nickel and black chrome are usually electro-plated onto a metal absorber plate. However, selective paints are now being developed. The use of a selective surface can increase the efficiency of a collector by about 10 per cent.

SENSIBLE HEAT
Heat stored in a medium (such as water, bricks or masonry walls) in which there is a temperature rise.

SERIES
Two or more systems connected in an additive manner. For example, 16 two-volt batteries connected in series will produce 32 volts.

SHORT TERM STORAGE
The heat storage of a solar heating system that is able to supply heat for only a few days. Because of the extended periods of cloud and extreme cold during our winters, a short term storage system can usually supply only 50 to 70 per cent of the house heating requirements.

SOLAR ENERGY
Generally describes those renewable energy sources which directly or indirectly are powered by the sun. They include: direct solar radiation, wind, falling water, biomass and waves. Solar energy is also used to specifically describe solar radiation.

SOLAR RADIATION
The electromagnetic radiation emitted by the sun. See INSOLATION.

SPLITTING MAUL
An implement used for splitting wood which is a combination of an axe and a wedge.

STICKLER
The brand name of a log splitting device which bolts on to the hub of a vehicle.

STORAGE VOLUME
The amount of heat stored in a solar heating system. A rule of thumb in calculating the required storage for a space heating water system is two gallons of water to each square foot of collector area. For an air-rock system, a half to one cubic foot of rock for each square foot of collector is suggested. These averages vary tremendously from one system to another; the determining factors are cost, availability and system type.

STRATIFICATION
The layering of different temperature levels within a given material. Stratification commonly occurs in rock storage and less often in water. In a rock storage with reverse flow, it is possible to have one end hot and the other relatively cool. This allows air from the cool end to be sent through the collectors, and air from the hot end to be fed to the house. This increases the efficiency of the system.

SUN
Our day star which is the source of life and virtually all energy flows on earth. These include direct radiation, wind, biomass, falling water, and waves. The sun is a fusion reactor, 93 million miles away, which each second converts about 4.5 million tons of hydrogen to pure energy giving a total output of 3.8 times 10^{23}kw. The earth intercepts approximately 2.2 billionths of this energy. See INSOLATION. The sun has an estimated life expectancy of 5 billion years and can be considered a renewable energy resource.

SYNCHRONOUS INVERTERS
A device which converts d.c. power to a.c. power of the same frequency and phaseof the electrical grid thereby making it compatible. It is then possible to use the grid and not batteries, for storage. This is done by feeding surplus wind generated power into the grid. When the wind dies down, power is drawn from the grid. Reversible, or dual meters, monitor the total electrical flow. Some electrical utilities in the U.S. are required to buy surplus wind-generated electricity. There are some Canadian utilities which are allowing experimental use of synchronous inverters.

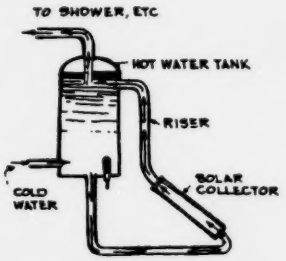
TEDLAR
A plastic film often used as glazing for collectors. Tedlar is often bonded to a fibreglass outer glazing to improve its weathering characteristics. It is a trade mark of DuPont.

THERMAL MASS
The heat storage capacity of a structure provided by large quantities of heavy material. This allows for very slow temperature fluctuations. See MASONRY WALLS.

THERMOCOUPLE
A heat sensing device used for measuring and monitoring temperatures within different parts of a solar system.

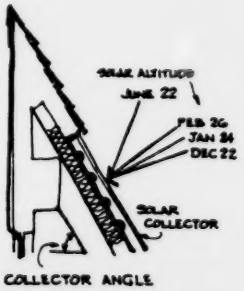
THERMOPANE
Refers to a sealed, double pane of glass.

THERMOSYPHON
The natural movement of heat caused by warm fluid rising and cooler fluid falling by gravity. Passive solar water or air systems which use the thermosyphon principle do not require pumps or fans.



THERMOSYPHON

TILT
Refers to the collector angle measured from the horizontal. A collector orientated south for a space heating system is generally placed at a tilt equal to the latitude of that particular location, plus 15 degrees. Ottawa, located at 45 degrees, would therefore have a collector tilt of 60 degrees (45+15). This maximizes the heat collected during the winter months when the sun is low on the horizon. Because collectors for domestic hot water operate on a year round basis, the tilt is generally equal to the latitude of the location. A solar domestic hot water system in Ottawa, therefore, would have a tilt of 45 degrees. Swimming pool systems which function in the spring, fall and summer are often placed at a tilt to equal the latitude minus 15 degrees. A system in Ottawa, therefore, would have a tilt of 30 degrees. The tilt may vary as much as plus or minus 15 degrees from the optimum without seriously affecting the system. Even 30 degree variations can be tolerated. For this reason, a south-facing vertical wall (90 degrees) can be an effective collecting area in Canada during the winter months, especially if snow-covered ground increases the reflected radiant energy that reaches the collector.



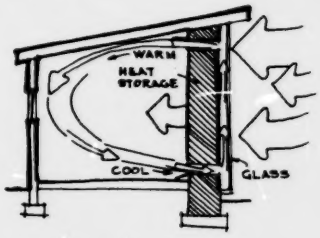
TILT

TIP-SPEED RATIO
The ratio of the speed of the tip of the rotor blade to the wind speed. It is usually between 6 and 8mph for wind generators. Therefore, in a 10mph wind the tips of the blades would move at 60 or 80mph.

TRANSLUCENT
Transmits electromagnetic radiation (light) but causes scattering so that no clear image can be seen.

TRANSPARENT
Transmits electromagnetic radiation without diffusion. A transparent surface, like window glass, is easy to see through.

TROMBE WALL
Also called Trombe-Michel. A vertical south-facing wall which acts as a passive solar collector. Insolation is absorbed by the glazed black wall and convection currents form between the glazing and the absorber. Vents at the top and the bottom of the wall allow cool room air into the collector, and heated air to be vented at the top to the room. The wall itself provides storage if it is of high enough thermal mass. A Trombe wall may also be made active by adding a fan and separate storage system.



TROMBE WALL

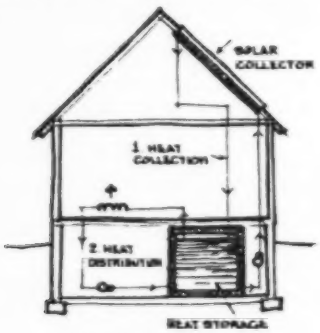
VERTICAL AXIS
A wind machine where the axis of rotation of the shaft is vertical. Typical examples include the Darrieus and Savonius machines. This type of mill can accept wind from any direction.

VERTICAL COLLECTORS
Collectors placed on a vertical wall (90 degrees). Vertical walls receive less insolation than collectors which are tilted at the optimum angle. However, the increased reflected radiation from the ground may compensate for this (especially when covered with snow).

VOLTAGE
Expresses the electric potential difference between two points of a conducting wire which causes the electrical current to flow. Houses are normally wired for 110 volts a.c. Cars are generally 12 volts d.c.

WATER COIL
A copper coil placed in the firebox of a wood stove to heat water. Water circulates automatically through the coil by thermosyphon action and can fully supply the domestic hot water requirements. Less efficient stoves sometimes have a water coil near the flue to collect energy which would normally go up the chimney.

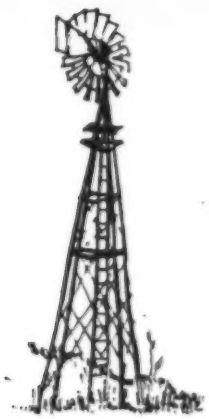
WATER SYSTEM
A solar collection system which uses water as the transport medium and usually, also, as the storage medium. Freezing must be prevented and corrosion inhibited.



WATER SYSTEM

WIND
An indirect form of solar energy. Wind is derived from local pressure differences which arise out of variations in physical topography, thermal capacity of air masses and the motion of the earth. It is a renewable energy source, and while intermittent, it can be considered predictable and reliable over the long term. See WIND REGIME.

WINDMILLS
Historically, a device for converting wind energy into mechanical energy to power grist mills and water pumps. Generally, refers to the family of wind machines. See MULTI-BLADE fan and SAVONIUS rotor.



WIND GENERATOR
A device for converting wind energy into electrical energy. Modern wind generators generally have only two or three blades which travel at about six times the speed of the slower multi-blade fans of traditional windmills.

WIND REGIME
The yearly average wind speed of a specific site or a general region. Most of Canada has a wind regime ranging from 8mph to 20mph. The regions of the highest winds are the St. Lawrence Basin, the Atlantic Coast, the west coasts of Hudson Bay, and southern Saskatchewan and Alberta. Selected sites may have a higher or lower wind regime than the surrounding area. Wind speed is increased by altitude, open ground and sometimes by travelling through valleys. Wind speed is decreased by turbulence caused by obstacles such as trees, buildings or hills.

WOOD

A renewable resource of indirect solar energy, once Canada's main energy source, today enjoying a rise in popularity. It can build our houses as well as heat them, power our cars, generate electricity, supply our paper and give us shade and beauty. Canada has about 388 million acres of primary forestry land which, if used properly, can provide an abundant resource.

WOOD LOT

Refers to a managed stand of trees which can supply fuel wood on a sustainable basis. Depending on soil, climatic conditions and the wood requirements, anywhere between five and twenty acres are required to heat a home on a sustainable basis. By culling the wind falls and the poorer quality trees for firewood, the growth and value of the remaining timber will actually increase.